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Carrot Production in the West and Southwest

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CONTENTS

CARROTS are an important vegetable food because of their large yield per acre, their high vitamin A value, their better than average calcium content and to a less extent their iron content. In addition, the golden-yellow color adds attractiveness to the foods on a plate. Carrots rank eighth among the various vegetables in annual per capita consumption, about 11 pounds.

Table 1 shows the average percentage composition of the edible portion of the carrot. A more recent way to express food values is in terms of the needs of an active man for the 9 nutrients. These standards were promulgated by the National Research Council and are given in footnote 3, table 1. In comparison with 28 other common vegetables, carrots rank high in vitamin A per pound of roots. Food energy, protein, and iron are about average when compared with the other important vegetables. Carrots are low in vitamin C, thiamine, riboflavin, and niacin.

Table 1.—*Composition of edible portion of carrots on several bases*

Item	Amount per 100 grams	Fresh roots[1]: Nutrients per pound as purchased: Nutrient units[3]	Fresh roots[1]: Nutrients per pound as purchased: Comparative rank based on 29 vegetables	Fresh roots[1]: Nutrients produced per acre (average California yields): Nutrient units[3]	Fresh roots[1]: Nutrients produced per acre (average California yields): Comparative rank based on 29 vegetables	Fresh roots[1]: Nutrients produced per man-hour: Nutrient units[3]	Fresh roots[1]: Nutrients produced per man-hour: Comparative rank based on 29 vegetables	Dried roots (nutrients per pound as purchased in nutrient units)[2,3]
Energy......	45 calories...	0.060	8½	1,019	4½	3.48	7½	0.45
Protein......	1.2 grams.....	.068	17½	1,155	8½	3.94	12½	.52
Calcium.....	42 milligrams	.210	3½	3,566	3½	12.18	7½	1.60
Iron.........	0.7 milligram.	.233	14½	3,956	5½	13.51	10½	1.79
Vitamin A..	2,300 U.S.P.....	1.838	3½	31,209	1½	106.60	2½	9.36
Vitamin C (ascorbic acid).	4 milligrams	.213	23½	3,617	22½	12.35	27½	1.10
Vitamin B_1 (thiamine).	0.042 milligram.	.093	20½	1,579	9½	5.39	19½	.58
Vitamin G (riboflavin).	0.043 milligram.	.064	18½	1,087	10½	3.71	15½	.37
Niacin......	0.210 milligram.	.047	26½	798	16½	2.73	25½	.30

[1] See MacGillivray, J. H., Shultis, A., Hanna, G. C., and Morgan, A. F. food values on a pound, acre, and man-hour basis for california fresh vegetables. Calif. Agr. Expt. Sta. Unnumb. Pub., 23 pp. [1943.] [Processed.] Carrots contain 88.2 percent of water; 88 percent of the root is edible, or there is 12 percent waste in preparation for serving. Nutrients produced per acre are based on the average yield of 22,640 pounds of bunched carrots, or 16,980 pounds of roots, for California from 1937 to 1941. Nutrients produced per man-hour are based on 77 pounds of bunched carrots, or 58 pounds of roots, produced per hour of labor from 1937 to 1941. Sources of composition are given in the leaflet cited. General analyses for United States were used except for vitamins, which were based on unpublished California analyses.

[2] See MacGillivray, J. H., Morgan, A. F., Hanna, G. C., and Shultis, A. food values on a pound, acre, and man-hour basis for california processed vegetables. Calif. Agr. Expt. Sta. Unnumb. Pub., 15 pp. [1943.] [Processed.]

[3] One unit represents the daily amount of each constituent necessary to nourish one man at active work according to the standards of the National Research Council. These amounts are as follows: Energy, 3,000 calories; protein, 70 grams; calcium, 0.8 gram; iron, 12 milligrams; vitamin A, 5,000 U.S.P.; vitamin C, 75 milligrams; vitamin B_1, 1.8 milligrams; vitamin G, 2.7 milligrams; and niacin, 18 milligrams.

The large production of carrots per acre is reflected in the amount of the 9 nutrients produced in comparison with 28 other vegetables. For most nutrients carrots rank near the top; only their niacin and vitamin C appear in the lower half of the list. Thus, carrots utilize land efficiently. The figures on nutrients produced per hour of labor are also favorable, since over half the nutrients produced per man-hour rank in the upper half in comparison with other vegetables. Carrots are probably the most distinctive and popular bunched root crop used for human food in the United States.

A number of factors are important in producing a successful crop of carrots. Among these are the selection of suitable soils, proper preparation of the land prior to planting, adequate fertilization, irrigation whenever needed to insure good growth, and finally good handling and packaging techniques.

Carrots are relatively free from damage by insects and are comparatively less susceptible to the common plant diseases than many other vegetable crops. However, carrots are very susceptible to injury from root knot nematodes. Fields known to be infested with these nematodes should not be used for carrots unless control measures, such as rotations and summer fallow, have been used to reduce the infestation.

The acreage devoted to commercial carrot production in the United States has increased more or less steadily from approximately 34,000 acres in 1930 to about 83,700 in 1943. The greater part of this increased acreage is in Arizona, California, and Texas; the acreage for the remainder of the country has remained almost stationary. This steady increase in acreage reflects the newer knowledge of nutrition in which the carrot is considered extremely valuable in the diet as a source of vitamin A.

The wild carrot (*Daucus carota* L.) is believed to be a native of Europe and adjacent parts of Asia. It has spread over the temperate regions of the globe and in some localities has become a troublesome weed. The wild form is an annual, from which the fleshy-rooted, biennial, cultivated form is thought to have been developed by selection.

The edible portion of the mature plant is an enlarged, fleshy storage organ, consisting mainly of taproot, except for about 1 inch of the upper portion, which is the enlarged stem. During the first season of growth the platelike stem develops a rosette of leaves; later it elongates to a height of 2 to 5 feet. These stems, or flower stalks, produce numerous small white flowers in terminal clusters. Later each flower develops into a single barbed, spiny fruit. At maturity each fruit separates into two fruitlets, each containing a single seed.

SOIL REQUIREMENTS

The carrot does well on many soil types. Well-drained sandy loam or organic soils such as peat are preferred; however, excellent yields and roots of good quality are produced on the heavy soils of the Imperial Valley of California and Salt River Valley of Arizona. The dark-colored, silty loams of the Salinas Valley of California also produce good yields of high-quality carrots.

Market carrots are usually grown on the lighter soils such as sandy loams and closely related types. Such soils are desirable because they can be easily worked when they are well drained and tend to produce smooth roots when they are adequately fertilized. Usually a fairly rapid growth is desired, because slow-growing roots may have an objectionably strong flavor and lack succulence. Carrots for canning or dehydration may be grown on heavier types of soil, since shape is not so important in roots for processing as in those for marketing. Furthermore, the heavier soils offer the advantages of greater fertility and water-holding capacity, with resultant greater yields. Peat soils will grow smooth roots that may be used for either marketing or processing.

Carrots require soils free of root knot nematodes and of average depth. They are classified as a moderately deep-rooted crop, having most of the root system in the top 4 feet of soil—an important consideration in fertilizer and irrigation practices. The amount of green material produced per acre, about 12 tons for average yields, indicates a rather heavy demand on the soil for mineral nutrients. Generally soils with a slightly acid reaction have been considered best for the development of the root. This cannot be true under all conditions, however, since excellent crops are produced on soils of the Imperial Valley, the Salt River Valley, and other formerly desert valleys where the soil reaction is slightly alkaline.

CLIMATIC AND OTHER ENVIRONMENTAL FACTORS

Effects of Weather on Carrot Development

Carrots are definitely a cool-weather crop, although they will withstand moderately high temperatures for short periods. Under excessively high temperatures the roots are inclined to deteriorate in quality, and a high percentage of plants are likely to bolt. Furthermore, high temperatures cause severe wilting, which makes harvesting and handling the crop without loss of quality difficult.

In California the bulk of the winter crop is produced in the inland valleys and the fall and spring crop, in the coastal Salinas and Santa Maria Valleys and adjacent districts. Some carrots are produced every month in the year in the Los Angeles district.

Some carefully controlled experimental work on the effects of temperature on growth has indicated that root growth is more nearly normal at 60° to 70° F. than at higher or lower temperatures. At temperatures higher than 70° the roots became abnormally short and blunted; at temperatures lower than 60° there was a tendency for them to become too lengthened and tapered. At the lowest temperature tested (40° to 50°) there was little if any enlargement of the root; in fact, the root became more like an ordinary taproot than a storage organ. Within the limits of the variety the shape of the root is governed for the most part by the average temperatures rather than by the daily maximum or minimum temperatures.

There is some evidence that an average temperature of about 65° F. is best for the production of the maximum amount of tops in most varieties. Below 50° top growth is very slow, and at temperatures of about 83° it tapers off rather sharply.

Effects of Environment on Carotene Content

For practical purposes it can be considered that most of the deep-orange or orange-red color of the carrot root is due to carotene, a substance that is widely distributed in plant and animal products. Yellow corn, yellow squash, egg yolk, and butter, for example, have visible amounts of carotene. With the discovery that carotene is the substance from which vitamin A is produced in the animal body, its importance in nutrition became obvious. The consumer is on sound ground in showing a preference for well-colored carrots. In addition to looking more attractive on the plate, they generally contain more carotene and have a greater vitamin A value than poorly colored ones. For these reasons it is important to have some knowledge of the environmental factors that affect carotene content.

There are fairly complete and dependable answers to some of the problems presented by the interrelation of carotene content and environmental conditions. It has been reported that increasing the length of day from 9 to 14 hours has no effect upon the color of the carrot root, but reducing the daylight period to 7 hours resulted in much lighter color as compared with 14 hours of light daily. The color is markedly influenced by the age of the root, however, increasing up to about 100 days after planting, after which there is only a slight change. During this period carotene tends also to become evenly distributed through the root. That is, the color distinction

between the core and other portions of the root gradually disappears, giving it a more uniform appearance in cross section. In the event of an actual deficiency of a nutrient element in the soil some change in the color of the root may occur, but under good fertilizer practice and on soils suitable for commercial production it is doubtful whether nutrients are important factors in the production of color. Carrots grown at 60° to 70° F. have the best color, whereas either excessive heat or cold impairs color. The color of the roots tends to be lighter in wet, waterlogged soils than in well-drained ones.

Figure 1.—Typical roots of Imperator carrot at marketable stage of maturity.

VARIETIES

In the West and Southwest where carrots are grown chiefly for bunching and dehydration, the varieties of importance are Imperator, Morse's Bunching, Red Core Chantenay, and Danvers Half Long.[1] Of these, Imperator and Morse's Bunching are the leading ones. The four varieties mentioned are described herein.

Imperator.—The Imperator carrot was introduced in 1928 by Associated Seed Growers, Inc. It has proved to be exceptionally well adapted for bunching under the conditions of culture in the Southwest and West. In

[1] For detailed descriptions of the principal varieties of orange-fleshed carrots, see Magruder, R., Boswell, V. R., Emsweller, S. L., and others. DESCRIPTIONS OF TYPES OF PRINCIPAL AMERICAN VARIETIES OF ORANGE-FLESHED CARROTS. U. S. Dept. Agr. Misc. Pub. 361, 48 pp., illus. 1940.

that region it makes a long, slightly tapered, well-colored root of good quality. It requires about 95 to 120 days to reach marketable size for bunching when grown as a winter or early-spring crop. The roots are harvested when they are 6 to 7 inches long and 1 to 1½ inches in diameter (fig. 1). The shoulders are square or slightly rounded; the flesh is deep orange with a somewhat yellower core. The foliage is large and strong and has a very attractive green color.

Figure 2.—Typical roots of Morse's Bunching carrot. (Courtesy of originator.)

Morse's Bunching.[2]—The Morse's Bunching carrot was introduced in 1934 by the Ferry-Morse Seed Co. Like Imperator, it requires about 95 to 120 days to reach marketable size for bunching when grown as a winter or early-spring crop. The roots are harvested when they are 6 to 9 inches long and 1 to 1¾ inches in diameter. At marketable maturity the roots are cylindrical and have rounded shoulders and stumped ends (fig. 2). The neck is small. The tops are shorter and more sparse than those of Imperator, but they are sufficiently strong for a good bunching carrot. The roots are smooth, well-colored, and uniform in cross section.

Red Core Chantenay.—The Red Core Chantenay carrot was introduced in 1929 by C. C. Morse & Co. It is a widely used, general-purpose variety of importance particularly for canning and storage, but it can also be used for bunching and dehydrating. It requires 90 to 120 days to reach marketable size for bunching when grown as a winter or early-spring crop. When harvested for bunching the roots are 4½ to 5½ inches long and 1¼ to 2 inches in diameter, tapering to a blunt end (fig. 3). The flesh and core are deep orange, and the quality is good. The shoulders are square to round, and the foliage is large and strong.

Figure 3.—Roots of Red Core Chantenay carrot, showing acceptable range in type at prime marketable stage of maturity.

Danvers Half Long.—The Danvers Half Long carrot was first listed in the United States for sale by Schlegel, Everett & Co. in 1871. It requires about 90 to 120 days to reach marketable size when grown as a winter or early-spring crop. The roots are 5 to 6 inches long and 1¼ to 1¾ inches thick when harvested for bunching (fig. 4). They taper to a more or less rounded end and have a deep-orange flesh and a slightly yellower core. The shoulders are round, and the foliage is large and strong at maturity.

SEED PRODUCTION

A major portion of the carrot seed produced in this country is grown in the Central Valley of California. Recently considerable carrot seed has been produced in some of the inland valleys of southern California and the Yuma district in Arizona. Plantings for seed production are made in July and August, and the young roots are ready for transplanting by late November or December.

[2] Information furnished by Ferry-Morse Seed Co.

Figure 4.—Roots of Danvers Half Long carrot, showing acceptable range in type at prime marketable stage of maturity.

At this point they should have reached marketable size, and they are pulled. All cracked, diseased, and offtype roots are discarded. The tops are clipped back to a length of 1 to 2 inches, and the selected roots are transplanted to the seed fields. They are normally set in rows, on the square, 32 by 32 inches or up to 36 by 36 inches, depending upon the variety. After transplanting, particular attention should be given to the management of soil moisture as the roots are very susceptible to rots of various sorts at this stage of development. The plants begin to bolt with the return of growing weather in late winter. As a rule the fields are in full flower by June (fig. 5), and harvesting is usually done in September. In southern California development is more rapid and harvesting can be done in June and July.

Seed heads may be either cut by hand and transferred to a canvas for threshing with a stationary machine or cut and threshed in one operation with a combine. After threshing, the seed is run through a cleaning mill and a rubbing machine. These two operations remove the coarse debris and spines from the seed. Although yields up to 1,000 pounds of seed per acre have been recorded, 400 to 600 pounds is considered an acceptable yield.

FIELD MANAGEMENT

Rotations

Carrots are grown in rotations about the same as lettuce. In the Imperial Valley the customary rotation is 3 to 4 years of lettuce or carrots followed by 3 years of alfalfa. If early lettuce is grown, a crop of late cantaloups may be produced the same year. Cantaloups are usually not combined with carrots in a single year because carrots occupy the land too long. If alfalfa land is to be used for carrots, it should be plowed before July 1 previous to planting in September. Plowed land left rough and exposed to the intense summer heat for at least 2 months is usually free of weeds when planted to carrots. This practice is also beneficial in the control of root knot nematodes. Slight modifications of these practices are used in all of the interior valleys where carrots are produced.

In the coastal valleys carrots are commonly rotated with other vegetable crops such as lettuce, peas, and beans. For green manure a mixture of sourclover (*Melilotus indica*) and purple vetch is ordinarily employed. The seed is sown in the fall, and the crop is disked and plowed in early spring. The land can then be prepared for a crop of carrots. If nematode infestation becomes a problem, onions and garlic rotated with carrots will give some measure of control.

Preparing the Soil

In preparing land for planting to carrots, there are two important principles to keep in mind. (1) The land should be thoroughly worked so that it is in condition to make a fairly smooth seedbed; a good seedbed is practically impossible in rough, cloddy soil. (2) The land should be properly graded to facilitate good irrigation. High and low spots in the field result in deficiencies or excesses of irrigation water. Lack of moisture and excess moisture in turn result in poor stands and uneven development of the roots. A typical set of operations which normally prepares the soil satisfactorily is to plow, level, float, flood, plow, disk, and float. The land should then be in condition for bedding and planting.

Figure 5.—Carrot field in full bloom.

Fertilizers

Under field conditions crops obtain nutrients from the soil as well as from the fertilizer added. In growing carrots for shipping in the Salinas district of California, 250 to 300 pounds of fertilizer per acre is applied; this fertilizer contains 8 to 16 percent of nitrogen, 10 to 20 percent of phosphoric acid, and 0 to 12 percent of potash. In growing them for dehydration, 300 to 500 pounds of a 10–10–5 fertilizer is used on both the lighter and the heavier soils. Soils in the Imperial Valley possess less available phosphoric acid than those near Salinas; therefore, 300 pounds of treble superphosphate is applied before planting. During the growing season this is followed by an application of 25 to 35 pounds of nitrogen as sodium nitrate (150 to 200 pounds) or ammonium sulfate (120 to 170 pounds) and usually about 25 to 45 pounds of nitrogen from ammonia gas (30 to 50 pounds applied in the irrigation water). Great care should be used as to the amount of nitrogen added in the last half of the growing season, since nitrogen applications at this time are likely to cause excessive development of leaves or top.

For the Salt River Valley and similar districts, the Arizona Agricultural Experiment Station recommends 300 to 400 pounds per acre of treble superphosphate applied broadcast or 150 to 300 pounds applied in bands at planting. Also about 300 pounds per acre of 10–20–0 or 11–22–0 fertilizer is broadcast or 150 to 200 pounds is applied in bands. The crop may be side-dressed 4 to 6 weeks before harvest with about 30 pounds of nitrogen as sodium nitrate, ammonium sulfate, or ammonia gas in the irrigation water.

Methods of applying fertilizers vary to a considerable degree among growers and areas. Superphosphate may be scattered over the ground by means of an endgate broadcaster with a horizontal whirling wheel. Either the ground is worked with a spring-tooth harrow previous to making the beds or beds are thrown up with a disk. In the Salinas Valley the phosphate may be applied on the level ground and the bed thrown up over the band so that the fertilizer is 4 inches below the surface when the bed is completed. Nitrogen, Ammo-Phos, or complete fertilizers are applied by means of a fertilizer drill with shoes that may be adjusted for depth. The fertilizer is applied 2 to 4 inches deep, 1 to 3 inches laterally from the seed, and in a band 1 inch wide. Fertilizer equipment may be attached to a cultivator or a tractor. Ammonia gas is applied in the irrigation water.

The use of manure or green manures is definitely recommended, because they increase both the organic matter and the available nutrients in the upper areas of the soil. In addition, organic matter increases the permeability of the soil to water, a very desirable feature. In Arizona about 8 to 10 tons of manure is applied per acre; this practice is also used in some parts of California, especially in the Salinas district. Since manure may cause a serious weed problem because of the seeds it carries, it should be applied to a previous crop with which weed control is not difficult or else used composted. Equipment has been developed for applying composted manure in bands, as done with commercial fertilizers.

Figure 6.—Carrot field in the Imperial Valley of California about 30 days before harvest.

Planting

In the Southwest carrots are planted in raised beds. This type of culture is an important feature of the planting, irrigation, cultivation, and harvesting practices in this region (fig. 6). The beds are usually 4 to 8 inches high after smoothing and about 40 inches from center to center; the raised portion is usually 18 to 20 inches in width, and the intervening furrows are of approximately the same width. The beds are thrown up with a triple or double lister; later they are smoothed and planted in one operation. Planters are adapted for planting carrot seed by attaching wide shoes. This modification permits the seed to be placed thinly in a broad band 3 to 5 inches in width rather than in a single straight line. Band placement of the seed gives the roots more space for growth, results in a minimum of malformed roots, and obviates the necessity for thinning the crop.

Depending upon the season when planting is done, 3 to 5 pounds of seed per acre is considered sufficient for a good stand; 4 pounds is an average rate. In early-fall plantings where trouble with germination and some destruction of the young plants by heat injury may be anticipated, 4½ to 5 pounds per acre is used. In later plantings it is best to use a smaller quantity in order to avoid crowding the plants in the row.

Irrigation

Good yields of carrots are obtained under irrigation practices that use rather widely different amounts of water under various conditions. This fact may be explained largely by differences in soil types and climate. Insufficient moisture will result in low yields, although in a few localities of the West the crop may be raised

without irrigation during the rainy season. Excessive amounts of water may decrease yields by leaching out the nitrates, by forming a high water table that interferes with growth, by limiting the volume of soil available for root development, or by producing a detrimental alkali content in the soil.

The soil acts as a reservoir for moisture. The total amount of water that must be applied to produce a crop of carrots is affected by the depth of the root system, the available water that a cubic foot of the soil can hold, and the distribution and amount of rainfall, temperature, humidity, and wind. Most of the water held in the top 3 to 6 inches of soil is evaporated to the air and does the plant little good. Carrots are classified as a moderately deep-rooted crop, along with beets, cucumbers, snap beans, and summer squash.

In general, sands hold less available water per foot of depth than loams, and clays hold the greatest amount.[3] Sandy soils exhausted of available water will hold 3/4 to 1 inch of irrigation water or rainfall per foot depth of soil, loams 1 to 1 3/4 inches, and clays 1 3/4 to 2 1/2 inches. If it is assumed that carrots will obtain water from the soil down to a depth of 4 feet, the maximum amount of available water that the soil could hold would be 3 to 4 inches for sands, 4 to 7 inches for loams, and 7 to 10 inches for clays. Since the crop will begin to suffer from lack of moisture before it can remove all the available water from the soil, carrots should be irrigated when one-third to one-half of such water is exhausted from sands and one-half to two-thirds from clays. The top few inches of soil may have been dried by the sun to a percentage lower than will support the plants; hence they may take proportionately more water than the amounts given above for the entire top foot of soil.

In California coastal areas having rains or receiving preirrigation, there is usually need for about 18 inches of additional water as irrigation; however, carrots are sometimes grown without irrigation. In the Imperial Valley and other warm interior valleys some 24 inches should be applied. Growers often use greater amounts where experience has shown that they will increase yields. In the Salinas district 4 to 8 irrigations are applied; in the Imperial Valley 10 to 12, or an irrigation every 7 to 10 days. In Arizona the fall crop receives 8 to 10 irrigations and the spring one, which develops much faster, 6 to 8. The amount applied is in the range of 18 to 25 inches in the Salinas Valley and of 30 to 36 inches in the Imperial Valley and in Arizona.

There are several methods of determining when the plants need additional water. As a rule, wilting or drooping of leaves does not occur on medium to deep soils until they have become much too dry. Carrots should be irrigated before any sign of wilting appears, since they may be able to obtain sufficient water to keep the leaves erect without having enough moisture to make the desired growth. However, the color of the foliage tends to be darker than the familiar medium green that indicates rapid development and sufficient moisture. The common procedure is to examine the soil in the root zone for soil moisture by means of an auger or soil tube. Usually a soil is darker in color when it contains a plentiful amount of water than when the available water has been removed down to or even near

[3] The amounts of water are expressed in terms similar to those used to record rainfall; an acre-inch is an inch of water over an area of 1 acre. One acre-inch of flowing water equals about 450 gallons per minute for 1 hour, or 1 cubic foot per second for 1 hour.

the permanent wilting percentage. Irrigated soils need to be checked during or after irrigation to insure that there is no dry soil in the root zone and that water has penetrated the beds laterally and completely wet the soil.

Cultivation and Weed Control

As carrot seed is slow to germinate and the young plants grow very slowly in the earlier stages of development, the weed problem generally becomes extremely important. If the field is not excessively weedy, the weeds can be kept under control by machine cultivation, followed by a moderate amount of hoeing. However, in very weedy fields machine cultivation is not effective and hoeing is usually too expensive to be justified by returns from the crop. Under such conditions it may be advisable to apply an oil spray to kill the weeds.

Stove oil[4] applied at the rate of about 45 to 60 gallons per acre for bed plantings and 65 to 85 gallons per acre for flat plantings, at pressures of 150 to 400 pounds, has been found by experience to give satisfactory results. The critical step in the use of stove oil for the control of weeds in carrot plantings is the selection of the proper time to apply the material. The application should be made when the young carrot plants have from *one* to *four true leaves* (fig. 7). If oil is applied when only the cotyledons (seed leaves) are showing, there is some danger of killing the carrot plants. Carrots sprayed after the four-leaf stage may retain some of the oil until harvest. *Although the oily flavor cannot be detected in the field, it becomes immediately apparent with cooking and makes the carrots unappetizing if not inedible.*

Figure 7.—Young carrot plants at the proper stages of development for spraying with stove oil to control weeds. From left to right, plants with one, two, three, and four true leaves.

[4] For detailed discussion of materials, dosages, time of application, etc., see Raynor, R. N. CHEMICAL WEEDING OF CARROTS WITH STOVE OIL SPRAYS. Calif. Agr. Col., Div. Bot. Unnumb. Rpt. 4 pp. Davis, Calif. 1943. (Rev. 1944.) [Processed.]

In addition to the precautions previously mentioned, there are several other points that must be rigidly adhered to if chemical weeding with stove oil is to be successful. (1) Use only stove oil, not any other fuel oil. (2) Apply only sufficient quantities to kill the weeds; in no case use over 100 gallons per acre. (3) Pull the sprayer through the field at a constant speed. Slowing up may cause an excess of oil to be deposited at one spot. If this happens, the carrots located in the immediate area should be destroyed, as a few oily carrots may cause an entire shipment to be judged unfit for market. (4) If it is necessary to stop in the field, the spraying apparatus should be shut off before stopping. (5) Oil-sprayed carrots should not be harvested before the oily flavor and odor, as determined by cooking tests, have disappeared.

Stove-oil sprays properly applied with adequate equipment and at the correct time control satisfactorily weeds at considerably less cost than hand hoeing. Although oil spraying is new and much needs to be learned about it, there is every reason to expect that weeding of carrots with stove-oil or other sprays may become an established practice in many carrot-producing regions.

After the weeds are eliminated from the fields and the young plants have attained a height of 3 to 4 inches, very little cultivation is necessary. A good thick stand of carrots produces a dense shade, which has a tendency to discourage weed growth except for the irrigation furrows where the weeds can be kept under control by a reasonable amount of cultivation.

In the Salinas district and to some extent in certain of the interior valleys it is customary to chisel at least three times before the crop is harvested. The chisel is a knifelike blade drawn through the center of the bed at a depth of 3 to 8 inches. At each successive operation the chisel is set at a greater depth until a maximum of 6 to 8 inches is reached. It is assumed that this practice promotes better root shape, but there is no evidence to show that it does.

HARVESTING, PACKING, AND TRANSPORTATION

Harvesting

Carrots are harvested when the majority of the roots reach a diameter of ¾ to 1½ inches at the crown. For dehydration the larger roots are considered the more desirable, but for bunching, the smaller ones, ¾ to 1¼ inches, are preferred.

Carrots are taken from the soil with a tractor-drawn implement designed specifically for this purpose. It usually consists of two subsoiler shanks placed about 20 inches apart (the width of the bed) and connected by a horizontal blade or knife about 4 inches wide from edge to back. The blade is set at about a 45° angle with the leading edge low; it may be adjusted to any desired depth, depending upon the length of root to be harvested.

A slight modification of the lifter just described is used by many growers. It is essentially the same as the ordinary carrot lifter, except that the two subsoiler shanks are bent sharply inward at the lower ends and are not connected by a steel blade (figs. 8 and 9). The curved or L-shaped subsoiler shanks act as a plow. The carrots are loosened from the soil and are easily pulled out and laid in rows. It has the advantage of not cutting the longer roots in beds containing carrots of markedly uneven lengths.

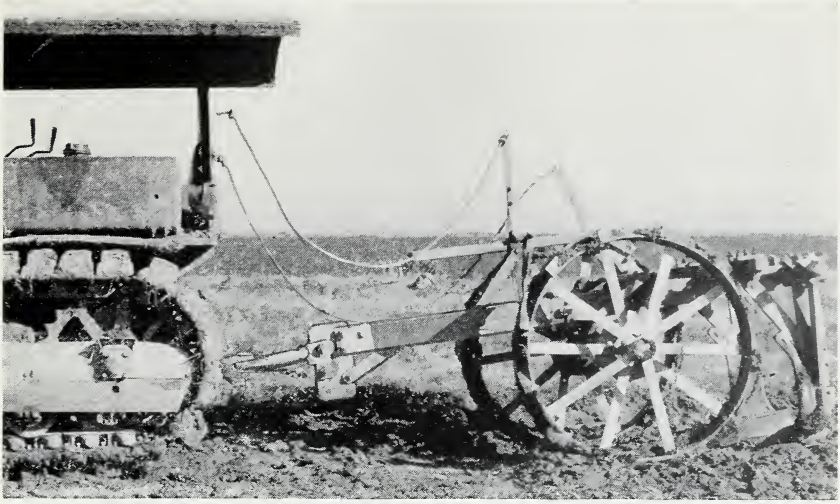

Figure 8.—Side view of a tractor-drawn carrot lifter.

The roots loosened by the lifter are then laid in rows for grading according to size; after grading they are bunched (fig. 10). Cracked, branched, sunburned, or poorly colored roots are discarded. Roots $3/4$ to 1 inch in diameter are tied 8 to 12 per bunch, those 1 to $1\frac{1}{2}$ inches in diameter 6 to 8, and larger ones with diameters of $1\frac{1}{2}$ to 2 inches only 4 to 6. By this system of grading all roots in 1 bunch are similar, the bunches are more attractive, and all contain approximately equal amounts of edible material. The bunches are tied with raffia, string, or a patented product consisting of a flat, rather stiff wire covered with paper. After bunching, the carrots are placed either in field crates or in trailers and hauled to the packing shed for washing, packing, icing, and subsequent rail shipment.

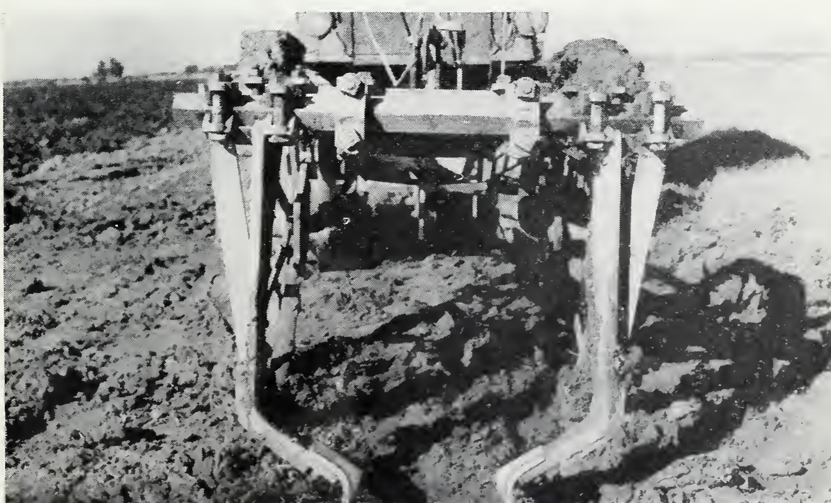

Figure 9.—Rear view of a carrot lifter.

Figure 10.—A carrot-harvesting scene, showing carrots laid out in rows ready for tying and carrot tiers at work.

Packing and Transportation

The carrot-packing shed consists essentially of a receiving platform, a series of large water vats or of machines for washing the roots, and some means of transporting the roots and crates through the routine of packing, icing, lidding, and loading into the car.

New methods and equipment for washing carrots are being developed and are rapidly replacing the older type of water vats. When vats are used the carrots are dumped from the field crates or trailers into the vat, agitated manually, and later removed from the vat by hand; the carrots are then packed in iced crates. Modern equipment for washing carrots consists of a long trough through which the water is pumped at considerable speed. The roots are dumped from the field crates into the trough and are floated by force of the water toward a hooded box, where they are carried up on a perforated draper and sprayed from two directions with water under considerable pressure. After leaving the spraying box they are taken on an endless belt past the packers, who place them in iced crates. The arrangement has a maximum capacity of about one carload of packed carrots per hour. These newer methods have the advantage of eliminating much hand labor, and they seem to do a more effective job of removing the soil from the roots than is possible by soaking and hand agitation in a water vat.

In transit carrots require as much refrigeration as any other fresh vegetable. They are usually shipped with ice in the package and over the top of the load, which keeps them at temperatures close to 32° F. Ordinarily they are not precooled.

If the roots are to be delivered to the dehydrator or marketed as topped carrots, the foliage is clipped from the root, so that only 1 to 2 inches remains with the root. The roots are then washed and in some cases run through a grading machine. This machine sorts them for size after which they are placed in bags or bushel baskets for delivery.

FIELD DISEASES AND THEIR CONTROL [5]

Bacterial Blight

Bacterial blight affects roots, leaves, flower stalks, and flower heads of the carrot. It was first described as a blight of seed heads, but later it was found as a root scab. The causal organism is a

Figure 11.—Carrot leaf naturally infected with bacterial blight, showing streaks on petiole and necrosis of leaflets.

[5] For additional information regarding disorders of carrots, consult the U. S. Department of Agriculture or the State Agricultural Experiment Stations.

Figure 12.—Flower heads of carrot infected with bacterial blight: *A*, Naturally infected flower head with only a few clusters affected; *B*, inflorescence with more than half the flower clusters affected.

bacterium, *Xanthomonas carotae* (Kend.) Dows. Carrots grown for seed and affected with the disease show irregular, necrotic spots on the leaves, brownish streaks on the stems and petioles, and necrosis of the floral parts (figs. 11 and 12). On the roots small to fairly large, narrow bands of brown to black areas are formed; later these may become raised or scabby and then coalesce (see fig. 14).

Figure 13.—Bacterial blight of carrot, illustrating root constrictions caused by early infection.

Infection may occur at any place on the root surface; affected areas extend laterally. Early infection frequently results in root constrictions (fig. 13) that make the roots unmarketable. Late infection usually results in numerous shallow, scabby lesions (fig. 14).

The causal bacterium is able to persist in the soil for some time and is known to be seed-borne. Continuous cropping with carrots

Figure 14.—Bacterial blight of carrot, illustrating the root scab phase of the disease. Diseased areas are usually raised, scabby, and brown to black.

and leaving infected culls in the field at harvest increase the occurrence of the disease. Plants from infected seed develop leaf spots but no root symptoms unless raised in contaminated land, but seed crops may become diseased when grown solely from infected seed. Soil contamination is not necessary for floral infection although it may aggravate it. Approximately 5 percent of the plants grown from seed known to be infected at planting time and planted in clean soil have been found to become diseased.

Bacterial blight may be avoided by planting disease-free seed in clean land; by treating infected seed in hot water at 126° F. for 10 minutes; by immersing contaminated seed in a 1:1,000 solution of mercuric chloride for 10 minutes, then rinsing, and drying. Clean or treated seed cannot produce a disease-free crop if sown on contaminated land.

Some of the chemicals mentioned in the treatments are injurious to man and animals when taken internally; a few of them are extremely poisonous. Therefore, care should be used in handling any of them to prevent their contact with the mouth, eyes, or nostrils. When these chemicals are used in dust form, care should be taken not to inhale them. When large quantities of seed are being treated with dusts, a respirator or dust mask should be worn. This warning also applies to the use of dusts on plants in the field. When small quantities of seed are treated in the open air or in a well-ventilated room the use of respirator or mask is not necessary. When large quantities of solutions are used, oiled leather gloves and a rubber or oilcloth apron should be worn. Care should be taken in pouring out the used solution to see that it soaks into the ground and does not stand in puddles. All vessels should be cleaned thoroughly after use, and clothing and hands should be washed.

Figure 15.—Late blight of carrot, caused by *Alternaria dauci*: *A*, Typical naturally infected leaf; *B*, naturally infected petioles.

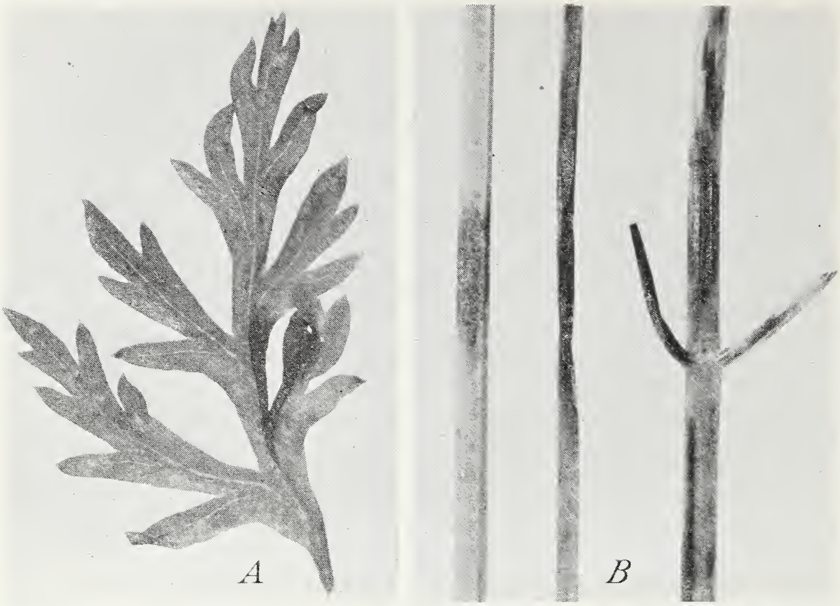

Figure 16.—Early blight of carrot, caused by *Cercospora carotae*: *A*, Typical naturally infected leaf; *B*, naturally infected petioles.

Late and Early Blights

Two distinct fungus blights affect carrots : late blight, caused by *Alternaria dauci* (Kuehn) Groves and Skolko (Ell. and Langl.), which usually occurs in fall-sown carrots, and early blight, caused by *Cercospora carotae* (Pass.) Solh., which usually occurs in spring-sown carrots. In California late blight occurs more frequently than early blight. Neither disease is prevalent to any extent in some growing districts, notably the Imperial Valley of California and the Yuma Valley of Arizona. Both fungi cause spotting and necrosis of the leaves; lower yields, poorer quality, and decay of packed carrots in transit result. Small, circular, distinct spots, which later may merge, are typical of late blight on leaves; necrotic spots also appear on the petioles (fig. 15). Diffuse, necrotic, irregularly shaped areas, usually causing inward curving of the leaf segments, are typical of early blight on leaves; petiole infection results in diffuse necrotic areas rather than in distinct spots (fig. 16).

Both blights may be controlled by spray applications of 5–5–50 bordeaux mixture or any of several proprietary copper materials. Application of copper-containing dusts may give satisfactory results in some areas, especially for the control of early blight; but such dusts are less satisfactory in combating late blight.

Cottony Rot

Carrots occasionally suffer from attacks by *Sclerotinia sclerotiorum* (Lib.) D By., which causes a wet soft rot of both tops and roots. The disease derives its common name from the cottony growth of the causal fungus, which is readily seen on roots, crowns, and leaves. Small, black, dry, bean-shaped, hard fungus bodies (sclerotia), which

perpetuate the fungus, may be found at the crown or on the leaves. Usually only the upper portion of the root is attacked; the infected tissue becomes soft and flaccid. The fungus spreads rapidly from top to bottom of the plants; infection is favored by moderate to low temperatures and high relative humidity.

Carrots should not follow crops known to have been infected by *Sclerotinia*, especially cabbage, celery, beans, and lettuce. Although on carrots the disease rarely warrants fungicidal control under western conditions, spraying with 5–5–50 bordeaux mixture satisfactorily controls it, provided the material is applied properly and the plants are thoroughly covered. Dusts containing copper are less satisfactory. Carrot stecklings must be carefully graded to eliminate roots affected with cottony rot from stock planted to raise seed. Disinfection of roots with Semesan Bel (1 pound to 7½ gallons of water) prior to setting will reduce the occurrence of the disease. (**See warnings,** p. 21.) No varieties of carrots are resistant to cottony rot.

Cottony rot may continue in transit and storage, where it is also called watery soft rot. The prevalence can be reduced somewhat by sanitation practices during harvest and packing to reduce contamination by the causal agent, by care in handling to reduce bruising and other mechanical injuries, and by careful culling to remove sources of infection. Prompt cooling of packed carrots and maintenance of low temperature are very important. Temperatures as low as practicable without freezing are needed to retard this rot, which progresses slowly even at 32° F.

Damping-off

Satisfactory carrot stands are usually obtained, but under certain field and weather conditions carrot seedlings die shortly after their emergence because of infection by certain fungi commonly found in the soil. Affected plants do not necessarily wilt, but the stems at the ground surface and the roots are usually discolored, the tissues become flaccid, and the plants finally collapse. This is known as postemergence damping-off. If poor stands are obtained, inspection of the seedbed may show that the seeds germinated but the plants rotted before they reached the surface of the soil. This is known as preemergence damping-off. Preemergence damping-off may be fairly well controlled by treating the seed before it is planted, planting at the best depth for good growth, and avoidance of excessive moisture in the seedbed. Seed may be treated as recommended by the manufacturers with Spergon (6 ounces per 100 pounds of seed), with Arasan (6 ounces per 100 pounds), or with Semesan (4 ounces per 100 pounds). (**See warnings,** p. 21.)

Root Constriction

One cause of root constrictions is early infection by *Xanthomonas carotae*, the organism causing bacterial blight of carrots (fig. 13). Irregularities in root diameter are not due solely to bacterial or fungus infections but frequently to purely physical factors such as irregularities in moisture supply, mechanical damage to the root tip, or heat injury (see fig. 18). Careful irrigation practices should be employed to assist in preventing uneven root diameters.

Root Knot

Carrots grown in nematode-infested ground develop poorly, may be stunted and yellow, and produce unmarketable roots. Affected roots are irregularly shaped, being distorted by the nematode galls (fig. 17). Nematode infection may be responsible for root forking also, but any mechanical injury to the root tip may also cause it. Nematodes may be controlled somewhat by reducing the populations through culture of immune, resistant, and trap crops. In arid areas, summer fallow followed by a period of irrigation to stimulate egg hatching and immediately by dry fallow is also beneficial. A new soil fumigant, DD mixture (dichloropropane-dichloropropylene), has been found in preliminary work to be very effective on the root knot nematodes. The material is usually applied by a machine which drills in the undiluted material at the rate of 200 pounds per acre to a depth of 6 inches by the continuous flow method at 12- to 18-inch spacing, or it can be used in emulsion form. After treatment with this material at least 2 or 3 weeks should elapse before planting the crop; otherwise some injury to the seed and young plants may occur from the fumigant.

In areas adapted to its culture, summer planting of crotalaria (*Crotalaria spectabilis*) as a trap crop will materially reduce the nematode population to a point permitting profitable carrot culture on lands previously unfitted because of root knot nematodes. No varieties of carrots resistant to infestation by nematodes are known.

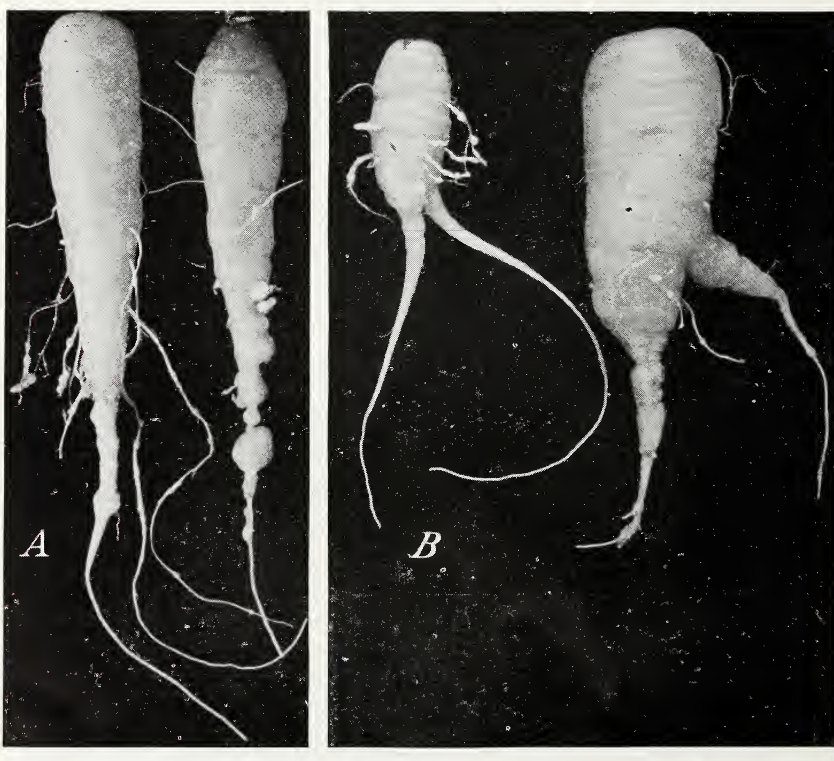

Figure 17.—Carrots affected by root knot nematodes: *A*, Roots showing galls; *B*, roots showing forking.

Figure 18.—Carrot seedlings damaged by heat.

Scab

Carrot scab is of rare occurrence and usually of little economic importance. The root surface may become roughened and pitted by somewhat corky, irregular spots caused by infection by *Actinomyces scabies* (Thaxt.) Güssow, the fungus responsible for potato scab. It is inadvisable to grow carrots on land that has yielded scabby potatoes.

Heat Injury of Seedlings

During hot weather young plants may wither and become brown and dry, usually near the ground surface; the crown of the plant, as well as the upper portion of the root, shrinks considerably (fig. 18). Some plants, especially young seedlings, collapse at the ground level. This damage is due purely to excessive heat. It must not be confused with damping-off, which is due to the action of parasitic fungi and is not usually associated with hot weather.

Bacterial Soft Rot

Carrot roots often are affected with slimy bacterial soft rot, caused by *Erwinia carotovora* (L. R. Jones) Holland. The causal organism gains entry into the root through any break in the skin, such as growth cracks or mechanical injuries. Market carrots under usual field conditions are seldom affected, but they may become diseased in transit or in storage if improperly handled. Bacterial soft rot is most important in stecklings used for seed production. Careful handling of planting stock is essential; only uninjured, healthy carrots should be used. When carrot roots planted for seed production are set out in irrigated lands, excessive irrigation should be avoided after planting because high soil moisture favors develop-

ment of bacterial soft rot. Use of raised beds somewhat reduces losses through providing adequate soil drainage. Dipping roots in New Improved Semesan (1 pound to 7½ gallons of water) or in Semesan (1 pound to 50 gallons of water) may be used as preventive measures. (**See warnings,** p. 21.) No varieties of carrots resistant to this disease are known.

Bacterial soft rot in transit and storage can be reduced as suggested for cottony rot (p. 23). Temperatures as low as 40° F., however, will retard this disease.

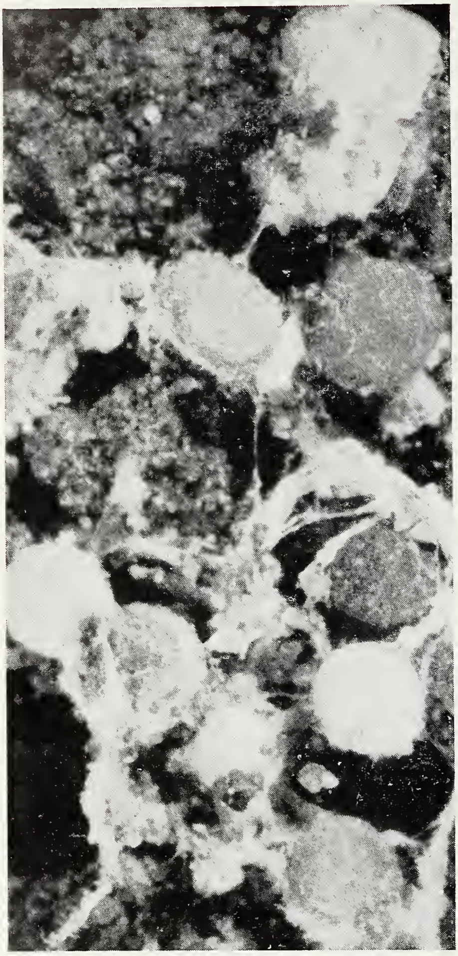

Figure 19.—Fungus bodies (sclerotia) of *Sclerotium rolfsii*, the cause of southern root rot. (× 10.)

Southern Root Rot

Carrots are extremely susceptible to southern root rot and should never be planted on land known to be infested or recently to have produced crops affected by the causal fungus, *Sclerotium rolfsii* Sacc. The fungus is perpetuated in the soil by means of the small, spherical, hard, yellow-brown fungus bodies (sclerotia), which may be found on the roots and stems of affected plants (fig. 19). Carrots affected by southern root rot usually die. The disease may first be noted by the presence of wilted tops. Upon digging the roots a firm, leathery, brown rot with white superficial mold and sclerotia resembling mustard seed is apparent. The disease may be spread by transporting carrots or equipment used in their cultivation or handling. Extreme precaution should be exercised in using equipment previously used in infested lands or in handling carrots taken from such lands. Equipment known to be contaminated should be thoroughly washed with a strong solution of formaldehyde (1 pint in 10 gallons of water) or disinfected with other sterilizing agents, such as steam or carbolic acid, before being used on disease-free carrot plantings. (**See warnings,** p. 21.)

Viroses

Two virus diseases which affect carrots are worth mention: mosaic, caused by the western celery mosaic virus (fig. 20) and by the

Figure 20.—Carrot leaflets (*A*, *B*) showing typical symptoms of infection by the western celery mosaic virus.

southern celery mosaic virus in the Gulf States; and yellows, caused by the aster yellows virus (fig. 21). Neither mosaic nor yellows is usually of importance in carrot plantings in the Western States, but they are known to cause losses in Texas. The leaves of mosaic-

Figure 21.—Carrot tops infected with aster yellows virus, showing (*A*) numerous adventitious shoots and (*B*) shortened flower stalks and malformed umbels with elongated raylets and pedicels.

affected plants are mottled yellow and green and are somewhat cupped and distorted; the plant is below normal size. Plants affected with yellows are stunted and have yellow, twisted leaves; their flowers are yellow green in contrast to the white ones of healthy plants. Both diseases are insect-transmitted—mosaic by aphids and yellows by leafhoppers.

MARKET DISEASES

There are a number of diseases which affect carrots in transit and storage. A few of these, such as bacterial soft rot (p. 25) and cottony rot (p. 22), occur in the field, but others do not. Such disorders as fusarium rot, gray mold rot, and rhizopus soft rot are solely market disorders.

Fusarium Rot

Fusarium rot is primarily a disease affecting mature carrot roots under storage conditions. Usually it is of no economic importance when roots are held at temperatures below 46° F. Various species of *Fusarium* are involved; they cause a spongy decay at the crown and sides of the roots. Fusarium rot may be recognized usually by the presence of a meager white mycelial growth of the fungus in the affected areas.

Gray Mold Rot

Topped carrots are more likely to be affected with gray mold rot than are bunched carrots. Various species of *Botrytis* cause water-soaked, light-brown areas, indiscriminately disposed over the root. Under favorable conditions for development of the fungus, a grayish-white mold forms; this may be covered with a velvety grayish-brown spore mass. Control measures are similar to those for bacterial soft rot and cottony rot. Temperatures as low as practicable should be employed, as the disease progresses slowly even at 32° F.

Rhizopus Soft Rot

Rhizopus soft rot is a common market disease of bunched and topped carrots, caused by the fungi *Rhizopus nigricans* Ehr. and *R. tritici* K. Saito. The affected root tissues become brown, water-soaked, soft, and watery. Coarse strands of mycelium, frequently topped by black fruiting bodies, readily distinguish this disease from bacterial soft rot. Maintenance of air temperatures below 50° F. will control rhizopus soft rot.

INSECTS AND THEIR CONTROL

Carrots are relatively free from destructive insect pests, but occasionally injury occurs. Those most likely to be encountered are mentioned herein.

Figure 22.—Carrots showing typical injury by wireworms.

Wireworms

The yellowish, cylindrical larvae of click beetles (chiefly of the genus *Limonius*) are known as wireworms. They often feed on the roots of carrots, causing unsightly blemishes and tunnels (fig. 22). As growth proceeds, this injury may cause a splitting of the carrot roots (fig. 23). These injuries may also allow the entrance of certain rot-producing fungi. At present the only feasible method of killing wireworms with chemicals is by soil fumigation. Crude naphthalene if mixed thoroughly with the soil at the rate of 500 pounds per acre gives effective control. Carbon disulfide is also very effective when injected into the soil at the rate of 900 pounds per acre, but its use is limited by its expense. Up to 1946 the new soil fumigants EDB (ethylene dibromide) and DD (p. 24) have given promising results against wireworms when used at the rates of 20 gallons of 10 percent (by volume) and 400 pounds per acre, respectively, but further investigations must be performed before they can be recommended for wireworm control. The rotation of carrots with grain, alfalfa, or other crops which result in the drying out of the soil has proved of benefit in reducing wireworm numbers. It has been found, on the other hand, that wireworms have a tendency to increase rapidly when red clover or sweetclover is grown more than one season on infested land.[6] Most truck crops grown continuously in the same soil also increase the number of wireworms.

Carrot Rust Fly

The carrot rust fly, *Psila rosae* (F.), is an important pest of carrots in the coastal districts of Oregon and Washington. The slender, legless, yellowish-white maggots, one-third inch long when fully grown, destroy the fibrous roots and tunnel in the fleshy roots. To

[6] For detailed information on the use of chemicals and crop rotations for wireworm control, consult the local agricultural authorities.

Figure 23.—Carrots showing splitting caused by wireworms.

prevent severe infestations of this fly, plant early carrots in those districts so that they may be harvested by July 15 and do not plant late carrots before June 1.

This insect may be controlled by application of crude naphthalene flakes, broadcast on the soil surface in the same manner as sowing grain by hand. Apply at the rate of 250 pounds per acre, or 1½ pounds to 100 feet of row. Three applications should be made at weekly intervals, beginning when the flies emerge. On early carrots in the districts mentioned this will be about May 10, and on late carrots about July 20 (emergence of second generation) and continuing until 1 month before harvest. *Carrots cannot be used for at least 1 month after applications of naphthalene, because they retain the flavor and odor of this material.*

A suspension of calomel may be used to control the carrot rust fly. To prepare this suspension, mix 3 ounces of calomel with a small quantity of water to make a paste and then add the paste to 10 gallons of water. Stir the suspension frequently to prevent settling. Apply to growing carrots at the rate of 1 gallon to 30 feet of row. Make the first application when the flies appear, as specified for the naphthalene treatment, and make two additional applications at weekly intervals. (**See warnings,** p. 21.)

Vegetable Weevil

The vegetable weevil, *Listroderes obliquus* Klug, occasionally damages carrots in California and in Texas; the adults and larvae feed on the foliage and on the roots. The adult is a brown to buff-colored snout beetle, ⅜ inch long and with two prominent tubercles located posteriorly on the wing covers. The legless larvae are green grubs ½ inch long when mature. In the winter and spring when damage commences, dusting with a 70- to 80-percent sodium fluosilicate dust or a 30- to 50-percent cryolite dust at the rate of from 15 to 50 pounds per acre, depending upon the density of the foliage,

often gives satisfactory control. **After such a treatment care should be taken not to utilize the tops for human or animal consumption because of the danger of poisoning.** (**See also warnings,** p. 21.) The destruction of weeds such as malva about the edges of the field should be a supplementary control measure.

Carrot Beetle

Larvae and adults of the carrot beetle, *Ligyrus gibbosus* (Deg.), are general feeders, but they often select carrots. The adults are robust beetles of the June beetle type, ranging from ½ to ⅝ inch long and having a uniform reddish-brown color. The whitish larvae or grubs feed on the roots only, but the adults feed both below and above ground. Damage often occurs in new plantings where native vegetation is grubbed out. Clean farming practices and crop rotation assist in averting serious injury.

Western Parsley Caterpillar

The beautiful green, black, and orange caterpillars of the butterfly *Papilio zelicaon* Lucas often feed on carrot foliage. Dusting with calcium arsenate or cryolite will afford control, but **the tops should not be eaten by human beings or animals because of the poisonous residue left on the plants.** (**See warnings,** p. 21.)

Cutworms and Armyworms

Caterpillars of the members of the moth family, *Phalaenidae* (*Noctuidae*), often attack carrots. For the control of cutworms, which are usually night feeders, a poisoned bait can be made as follows:

Sodium fluosilicate or paris green	1 pound
Bran	25 pounds
Water (sufficient to make a dry mash)	4 or 5 gallons

In preparing the bait the poison is mixed dry with the bran. Next add the water to the dry mixture while stirring. Continue to add water until a crumbly mash consistency is obtained. Usually 10 to 15 pounds of the wet bait per acre is spread in the early evening. For armyworms, which feed more often on the foliage, arsenical or cryolite dusts can be used **provided adequate precautions are taken against the subsequent use of the tops for food.** (**See warnings,** p. 21.)

Six-spotted Leafhopper

The six-spotted leafhopper, *Macrosteles divisus* (Uhl.), is important as it transmits the virus causing aster yellows (p. 27). According to W. H. Ewart [7] carrots in the Winter Garden district of Texas harvested between December and March sustained average losses of from 35 to 50 percent from this disease during the 1943–44 season. Losses are severe also in the Southwest.

[7] In correspondence, February 3, 1945.

The Cabbage Looper

The caterpillars of the cabbage looper, *Trichoplusia ni* (Hbn.), feed on carrots in the South during any season, but they are particularly destructive to seedlings in September and October. Dusting with pyrethrum, cryolite, or arsenicals usually gives satisfactory control. Two applications at 10-day intervals may be necessary. (**See warnings,** p. 21.)

The Wingless May Beetle

The adults of the wingless May beetle, *Phyllophaga cribrosa* Lec., are destructive to carrots in Texas, where they migrate from uncultivated to cultivated areas. They may destroy entire plantings in September and October, when the plants are in the seedling stage. Control consists in using trap furrows about the fields supplemented by the use of standard cutworm baits mentioned on page 31.

Insects of Occasional Importance

Two eriophid mites occur on carrots in California: namely, celery rust mite, *Phyllocoptes* (*Vasates*) *eurynotus* Nalepa, which causes a russeting of the leaves and stems, and *Eriophyes* (*Aceria*) *peucedani* (Can.). The clover or almond mite, *Bryobia praetiosa* Koch, occasionally infests carrots during the winter. Carrots are attacked by numerous species of aphids including the following: The rusty-banded aphid, *Aphis ferruginea-striata* Essig, which occurs about the crowns; *Rhopalosiphum conii* (Davidson); *Cavariella capreae* (Fab.); and *Aphis helichrysi* Kalt. The carrot weevils, *Listronotus latiusculus* (Bohe) and *L. rudipennis* Blatchley, attack carrots occasionally. Blister beetles, including *Macrobasis unicolor* Kby. and *Epicauta* spp., often attack carrot foliage. Grasshoppers, which occasionally injure carrots during the fall, are controlled by standard bait application (p. 31).

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